REMARKS/ARGUMENTS

Favorable reconsideration of the present application is respectfully requested.

Claim 1 has been amended to include the feature of Claim 2 whereby a plurality of light transmitting windows are provided. Claims 1 and 2 have also been amended to recite that the light transmitting windows are "rigid." Basis for this is believed to be evident from the description that the windows are made from synthetic quartz, for example. Claims 1 and 2 have also been amended to recite that the windows are located on a light path from the light source. Basis for this is evident from Figures 1, 2, 4A and 4B. Claims 1 and 2 have also been amended to recite a support member positioned on one surface of the reaction chamber, and beams fixed on the support member and positioned between the light transmitting windows to support each of the light transmitting windows with air tightness. Basis for this is found in the beams 15 illustrated in the embodiments. Claims 1 and 2 have also been amended to recite a substrate holder having a region on an upper surface of the substrate holder to hold a substrate to be processed. Basis for this is found in the substrate holder 7 of the embodiment, on which the substrate 6 may be placed.

The "check" pattern of Claim 5 has been changed to "checkerboard" pattern. Basis for this is believed to be evident from a "check" pattern. Claim 18 has been amended to recite the elements of the groups 12-16 of the periodic table, as set forth on page 46 of the specification. New Claims 21-23 recite that the light transmitting windows are juxtaposed in the moving or swinging directions. Basis for this is found in the first three lines of original Claim 8.

Applicants with to thank Examiner Bueker for the courtesy of an interview on December 16, 2005, at which time the outstanding rejections were discussed, as were possible amendments. Based upon the discussion held at that time, it is Applicants'

understanding that the present claim amendments overcome the rejection under 35 U.S.C. § 112, second paragraph.

According to a feature of the invention set forth in the claims, a driving mechanism linearly moves or swings a substrate holder in a direction parallel to a surface to be processed. This permits the width of the light transmitting window in the moving direction to be made smaller then the length of the substrate or a region of the substrate holder in the moving direction while avoiding unevenness in processing due to shadows of beams supporting the light transmitting window. One can therefore provide a plurality of light transmitting windows. For example, referring to the non-limiting embodiments, a driving mechanism 34 moves a substrate holder 7 in the direction B2 which is parallel to the surface to be processed. Therefore, the plural light transmitting windows 4 have widths smaller than the length of the region of the substrate holder which holds the substrate.

As discussed during the interview, the Sakuma et al references disclose a thermal processing system in which a single light transmitting window 68 is supported by a frame member 66 including intermediate frames 72 (Figure 11) so that the pressure on the transmitting window is improved (column 8, lines 19-38 and column 11, lines 17-35). The Sakuma et al references thus fail to disclose a plurality of windows, but instead disclose a single window supported by a frame. Therefore, Sakuma also lacks the presently claimed feature of support "with air tightness." For this reason alone, the claims define over the Sakuma references.

Claim 1 further recites a driving mechanism which linearly moves the region of the substrate holder relative to the light transmitting window in one direction parallel to the surface to be processed. Claim 2 recites a driving mechanism which linearly swings the region of the substrate holder relative to the light transmitting window in a direction parallel to the surface to be processed. Sakuma et al, on the other hand, does not *linearly* move or

swing the substrate holder, but instead *rotates* the substrate holder in order to more evenly heat the substrate (column 1, lines 29-34).

During the aforementioned interview, the Examiner posited that linearly moving a substrate holder was known in the art, for example as taught by the references cited against Claims 6-8 to teach a step of moving a substrate in a reciprocating motion or swinging motion. However, none of these references would suggest the linear movement or swinging now recited in the claims.

For example, Tolt describes "The substrate is permitted to rotate back-and-forth... ." Although Murakami (Fig. 7) shows that a substrate can rotate and move in parallel and transversal direction with respect to the gas flow (column 2, lines 36-59), the invention is a CVD apparatus having gas nozzles 4-1 through 4-4 on the upper section, and is different from the light processing apparatus of the present application. Although Miller (Fig. 17) discloses that a chuck 120 linearly moves in a drive assembly 218, the invention is also a CVD apparatus having an injection assembly 160 on the upper section. Wertheimer (Figs. 1-4) is not a light processing apparatus, but a plasma processing apparatus using microwaves. This is clear as reference numeral 19 denotes a microwave window and not a light transmitting window.

Claim 12 was rejected under 35 U.S.C. § 103 as being obvious over Sakuma in view of Iwasaki and Maeda, which were cited to teach that it is desirable to place another chamber adjacent to a lamp processing chamber of the type taught by Sakuma. Although Iwasaki (5,174,881) discloses a CVD chamber adjacent to a preprocessing chamber having a mercury lamp 1, the pre-processing chamber does not comprise the structural elements of Claim 1. Although in Maeda (5,314,538), a wafer moves between multiple chambers, Maeda does not comprise the structural element of claim 1.

Claim 13 was rejected under 35 U.S.C. § 103 as being obvious over Sakuma in view of Takasu, Inayoshi or Iwasaki, each of which was cited to teach that a low pressure mercury lamp can be used for photochemical processing of a substrate held in a vacuum chamber. Similarly, Claims 14, 15 and 17 were rejected under 35 U.S.C. § 103 as being obvious over Sakuma in view of the admitted prior art of Figure 12. Claim 18 was rejected under 35 U.S.C. § 103 as being obvious over Sakuma in view of Beinglass. Claim 20 was rejected under 35 U.S.C. § 103 as being obvious over Sakuma in view of Iwasaki, Shinriki, Beinglass and Nakata.

Although the references to Takasu (5,261,961), Inayoshi (JP 2-182883) and Iwasaki (5,174,881) disclose using a low-pressure mercury lamp, the references do not comprise the structural elements of Claims 1, 2 and 16.

Beinglass (column 1, lines 18-39) discloses the technology of depositing a silicon doping layer using a CVD process in which a dopant gas (phosphine, arsine, etc.) is used, and the gas is heated by a high intensity lamps 138. However, Beinglass is not a light processing apparatus, and does not comprise the structural elements of Claims 1, 2 and 16.

Shinriki and Nakata (Asia Display/IDW '01) do not comprise the structural elements of Claims 1, 2 and 16.

New Claims 21-23 further define the moving or swinging direction as being in the direction that the light transmitting windows are juxtaposed. This is also not taught in the prior art.

Applicants note that the Examiner has not considered reference AY of the IDS filed on December 30, 2003 because no copy of this reference is in the official record. Applicants note, however, that copies of five references were cited on that date, as evidenced by the attached date-stamped filing receipt. For the Examiner's convenience, Applicants are submitting a further copy of the reference AY, "*Low Temperature Oxide Formation for Poly-*

Si TFT by Plasma and Light Process" (see specification, page 2, lines 7-17). Consideration of this reference is therefore respectfully solicited.

Applicants therefore believe that the present application is in a condition for allowance and respectfully solicit an early Notice of Allowability.

Respectfully submitted,

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高濃度オゾンを用いたシリコン酸化プロセスとその特徴

Oxidation process of Si with highly concentrated ozone gas and its characteristics

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我々は、①低い運動エネルギー（< 1eV）、②高い反応活性度、③電気的に中性、などの特色を有する活性粒子を表面プロセスに応用する立場で研究を進めている。現在対象としている活性粒子はオゾンであり、高濃度オゾンビーム発生・供給装置を試作し、シリコン基板の酸化プロセスへの応用を検討している。これまで、減圧環境（数十 Pa 以下）で 80%以上、大気圧環境で 30%以上の濃度を有する高濃度オゾンガス発生装置を作製し、熱速度（0.02eV 程度）のオゾンガスを用いてシリコン基板（Si(100)面）の初期酸化過程を調べ、次の事を明らかにしてきた[1-4]。

1）オゾンによるシリコン酸化では、オゾンから解離生成する原子状酸素（通常は基底状態：$O(^3P)$）が反応に関与する。原子状酸素は高い反応確率でシリコンのバックボンド側に挿入する。このため、酸素ガスに対しては酸化耐性がある水素終端表面でも、オゾンによる酸化は進行する。

2）同一温度（<700℃）、同一圧力条件で、高濃度オゾンガスを用いると酸素ガスに較べて高い酸化速度が実現できる。同時に、オゾンでは完全な Si-O-Si ネットワークの形成が進行するため、サブオキサイドの形成が抑えられる。

3）オゾンによる酸化膜の初期成長では、Langmuir 型の層成長様式が観測される。層成長に伴う界面荒れは小さく、原子ステップが保存される。

4）基板温度が 350℃程度で作製したオゾン酸化膜でも、高い稠密性を示す。（希釈 HF によるエッチング速度で評価。）但し、熱酸化膜と異なって、酸化膜ーシリコン基板界面付近で、構造遷移領域が顕著に現れない。

図 1 は、オゾン及び酸素分子で作製した酸化膜の中エネルギーイオン散乱分光法（MEIS)による測定結果で、Si のブロッキングピークから測定した、シリコン基板ー酸化膜界面付近での Si 原子の変位を示すものである。オゾン酸化膜（▲）に比べて酸素酸化膜（■）での構造遷移領域が顕著に現れていることがわかる。

活性粒子（オゾン）による酸化では、入射するオゾンの運動エネルギー、指向性を高めることによる反応性・制御性の改善が期待できる。我々は、純固体オゾンのレーザーアブレーションによる超熱速度（～1eV）オゾンビームの発生と酸化プロセスへの応用も併せて検討しており[5]、それによるシリコン酸化の特性改善結果も併せて紹介する。

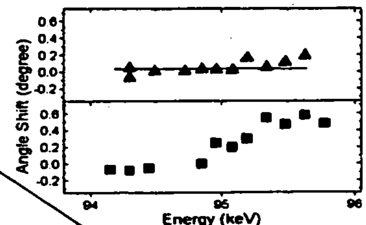

図 1　MEIS で測定したシリコン基板ー酸化膜界面の原子変位。オゾン酸化膜（▲）と酸素酸化膜（■）の比較

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プラズマ、光プロセスによるポリシリコン TFT 用低温酸化膜形成

Low Temperature Oxide Formation for Poly-Si TFT by Plasma and Light Process

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【1】緒　言

a-SiTFT のゲート絶縁膜は、最初の報告[1]ですでに a-SiNx が用いられていた。a-Si との界面も問題なく、逆スタッガ型 TFT 構造でなるべく高い温度でゲート a-SiNx を成膜し組成を制御することにより信頼性も問題なかった。しかし、Poly-SiTFT のゲート絶縁膜は、LSI のように熱酸化は用いることが出来ず 600℃以下でゲート絶縁膜を形成すること、ガラス基板およびこれに含まれるパネルの面積が LSI より大きいため大面積に良品率良く絶縁膜を形成することが必要であった。

【2】現　状

現在はゲート絶縁膜を TEOS ガスを用い PE-CVD 法で形成する方法が最も良く用いられている。しかし TEOS＋O2 ガスから成膜した SiO2 膜は、原料ガスからの炭素不純物の混入が避けられず基板温度 350℃で 1．1 $X10^{+20}$ 原子/cm3 含み、特に成膜温度を 350℃から 200℃に下げると 1．2 $X10^{+20}$ 原子/cm3 約 1 桁増加することが判った。このため SiH4＋N2O ガスを用い低温酸化膜形成を検討した。

【3】プラズマ領域制御

プラズマ発生領域を制御して成膜した SiO2 膜はリーク電流を減少できた。[2] この特性改善の原因は、プラズマ密度が高くなったためと考えられる。この膜は炭素は含まないが、フラットバンド電圧が大きく、この原因は界面固定電荷であることが判った。このため、SiH4＋N2O ガスを用い SiO2/Si 界面特性を改善することにより、低温で高品質なゲート絶縁膜を形成できる可能性がある。

【4】光 酸 化

酸化工程は、界面を Si バルク内に押し込んで作製できるため、良好な SiO2/Si 界面を形成できる。この酸化方法として、Kr/O2 プラズマ[3]、リモートプラズマ酸素活性種[4]、オゾン酸化、高圧酸化等が開発されている。

我々は、イオン衝撃を無くした光酸化を検討した。Xe エキシマランプからの波長 172nm の光を用いることにより、オゾンを経ずに直接に効率よく酸素原子活性種を作製できる。また、光酸化、光 CVD、光 CVD＋PECVD、PECVD を真空を破らずに連続しておこなえるように PE-CVD 装置を改造した。

基板温度 300℃で酸素ガス圧を変えて光酸化速度を測定した。30 分の光酸化で膜厚 1.5nm が得られ、また光酸化速度を早くする最適酸素ガス圧が存在することが判った。

また、SiH4+N2O から PECVD 法で作製した SiO2 膜の界面に薄い酸化膜を挿入することで、界面特性が改善することが判った。

【5】謝　　辞

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